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Research Article

GEOLOGICAL AND STRUCTURAL FACTORS OF PLACEMENT OF ORE-GRADE GOLD OF KOCHBULAK DEPOSIT AND THEIR INFLUENCE ON THE RESERVE CALCULATIONS (MIDDLE TIEN SHAN, UZBEKISTAN)

***Maksud Isokov**
Department of Sector of Cabinet of Ministers of the Republic of Uzbekistan, 11A, T. Shevchenko str., Tashkent – 100060, Uzbekistan
**Author for Correspondence*

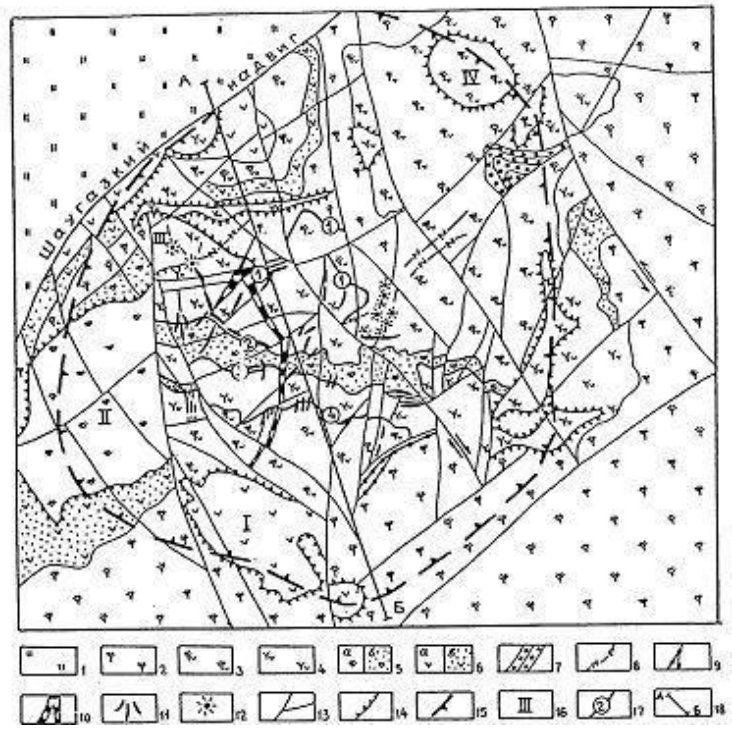
ABSTRACT
In the article geological and structural factors of placement of ore-grade gold of Kochbulak deposit and their influence on an calculations of reserves are considered. It is shown that the leading role in localization of industrial ore bodies and allocation of ore grade gold in Kochbulak deposit is played by the structural factors developing against lithologic, fixed in a tendency of increase of the content of gold in lava breccia of andesite porphyrite and lithic tuff of andesite structure. Influence of structural factors in many respects predetermines complications of geological borders, features of morphology, contours of ore bodies and distribution of an industrial ore grade gold in them. Practice advices are provided regarding increase of degree of reliability of prospecting information and estimation of reserves on similar fields for minimization of divergences of the exploration data and operation.

Keywords: *Kochbulak Deposit, Reserve Calculations, Volumetric Data*

INTRODUCTION
On the example of one of large gold ore objects of Uzbekistan it is considered occurrences of factors of placement of ore-grade gold on reserve calculations. Because of difficult geological and structural conditions of deposit formation during exploitation the deviations in estimated parameters are noted.

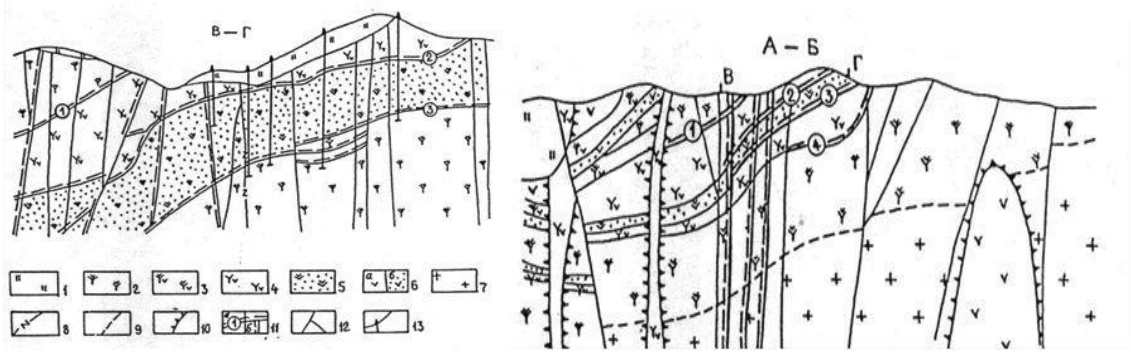
Study Area
Kochbulak gold ore deposit is one of large objects of modern mineral raw material base of gold of Uzbekistan. It is located in the Chatkal-Kurama region (Uzbekistan part of Middle Tien Shan), in the Beltau-Kurama axial zone of the vulcano-plutonic belt (VPB) on the active margin of the Kazakhstan-Kyrgyz microcontinent in northwest margin part of a large Lashkerek volcano-tectonical cauldron (Figure 1, 2).
Works of many scientists are devoted to studying of geology problems and prospects of ore-grade gold of the region:.
Kochbulak gold ore deposit was stricken in the second half of last century. Now it is explored on depth for more than 700 m, but indicators of feathering out were not observed.
According to its genesis deposit belongs to the category of very large-scale deposits of epithermal type (Krippl-Krik type).
According to geological and industrial classification of gold deposits applied in Uzbekistan it belongs to gold sulphidic quartz type.

MATERIALS AND METHODS
Research Method
The classification of exploration methods and exploration systems of region deposits for reserve calculations, including Kochbulak deposit, traditionally is based on the revealed regularities placement of mineral and structural-morphological features of ore bodies.



1 - Meso-Cainozoic Deposits; 2-7 - Volcanits of the Middle and Upper Carbonic: 2 - Trachyandesites; 3– Trachyandesite=Dacites; 4 – Andesite-Dacites; 5 - Trachydacites (a) and their Tuffs (b); 6 - Dacites (a) and their Tuffs (b); 7 - Vulcanomictous Sandstones, Gravelites; 8-10 - Dikes of Permian: 8 – Diabasic Porphyrites; 9 – Quartz Porphyry; 10 - Granosyenite-Porphyry; 11- Ore Bodies; 12 - Chimney Ore Bodies; 13 - Faults; 14 - Contours of Subvolcanic Bodies; 15 - Supposititous Contour of the Kochbulak Caldera; 16 – Subvolcanic Bodies: Kelenchaktash (I), Sharak (II), Semgran (III), Karatash (IV); Nishbash (V); 17 – Flat-Lying Crushed Vein Zones: Nishbash (1), Uzun (2); Kalta (3), Chetgi (4); 18 - Lines of Geological and Structural Section

Figure 1: Geological and Structural Scheme of Kochbulak Ore Field



1 – Meso-Cainozoic Formations; 2 – Trachyandesites; 3 – Trachyandesite=Dacites; 4 – Andesite-Dacites; 5 – Trachydacites; 6 – Dacites (a) and their Tuffs (b); 7 – Granitoids of Middle-Carbonic; 8 – Diabasic Porphyrites; 9 – Supposititous Geologic Boundary; 10 – Subvolcanic Bodies; 11 –Crushed Vein Zones: а – Flat-Lying (1 - Nishbash; 2 - Uzun; 3 - Kalta; 4 - Chetgi , б – High-Dipping; 12 – Faults; 13 – Drilled Wells

Figure 2: Geological and Structural Sections in the Line of А-Б and В-Г

The Uzbekistan gold deposits are complex, with very non uniform distribution of ore-grade gold ("Classification of deposit reserve and expected resources of solid minerals", 1999), when definition of ore bodies morphology is complicated.

So far, five phases of exploration are carried out in Kochbulak. According to prospecting works (Zimalina *et al.*, 2015) on the areas of a Kochbulak deposit there are about 200 quartz veins and zones of silification are revealed and explored. Ore bodies are concentrated in 32 ore-bearing structures united in 23 ore-bearing zones, mainly on Centralnyi area and Tokberda area and less on Zapadnyi, Semgran and Sharak

areas.

On the basis of the analysis of the exploration data and operation (plans, sections, geological documentation of prospecting and operational developments, etc.) systematization of structural and morphological types of ore bodies with the characteristic of geological and structural positions of ore-grade ore placement (Isokov, 2016), defining of exploration technique and reliability of its results.

Industrial ore bodies of the 1st morphological type, under the terms of orientation in space in the relation to the ore-hosting environment, are subdivided into two structural types: concordants flat-dipping, limited to zones of interformational and interstratal stripping and intersecting high-dipping, spatially combined by radial throw, throw-over thrust and their echelon shear fractures (Table 1).

On an internal structure ore bodies of the first structural type are typical zones of an silicification. Their basis consists of "core veins" 20-40 cm, spatially separated by strongly silicified with containing breeds penetrated by thin streaks of quartz. Ore bodies are characterized by very non uniform distribution and rather low contents of gold. Conditions of their formation are caused by flat-dipping interformational and interstratal stripping of tectonic nature.

For each morphological type it is allocated the most characteristic for concentration of industrial ores their parts (areas) in volume of the general contours of ore localizings structures and their structural and tectonic position (Figure 3):

a) flat-dipping vein of silicified and spalling rock in porphyrites of andesitic structure (ore body 201);
b) flat-dipping quartz vein on contact of the blocking andesite-dacite porphyrite and underlying lithic tuff of andesite structure crossed with high-dipping faults including ones with quartz filling (ore body 15);
c) flat dipping quartz vein in the andezite porphyrites crossed with high dipping faults (ore body 35);
d) flat deposit of silicified rock in a step fold of ore controlling structure on the strike (ore body 200);
e) flat deposit of silificied rock on a site of conjunction of ore localizing ruptural structures (ore body 200).

Thus, the carried-out analysis of prospecting and operational data showed that in ore bodies it is allocated structural and textural factors, that is crossing of fissures of different systems, conjunction of fissures, bending of fractures, etc. of smaller scale, than an ore body. In amount of explored bodies (46) crosscutting high-dipping bodies are more considerable industrially. Flat and abrupt ore bodies in the mineralized and vein zones, as a rule, have no clear geological boundary, they are characterized by the extremely non uniform distribution of mineralization, and their contours are defined generally according to approbation. Quartz-gold blocks and nested structure of ore congestions, where there are areas with the high content of gold, interstratified with the barren ones. Despite the small sizes the considerable reserves of gold are concentrated in them. Nine such ore bodies are explored that are located in the northeast (Tokberda area) and in the northwest (Zapadnyi area) of deposit. Separate ore bodies according to reserves of metals can be considered as independent objects of an industrial development. Detailed researches on comparison of the exploration and exploitation data are carried out on ore bodies of all three morphological types (chimney, flat and high dipping).

Apparently from figure 4 displaying high-dipping, flat-dipping and pipelike ore bodies of Kochbulak, the general configuration of ore bodies is not changed. However, at an overlay of mineralization contours one upon the other their spatial dissociation is noted. On a section on an ore body No. 30 it is visible that it is displaced by a flat-dipping zone of Kalt. At an exploration stage it is not recorded. This shift influence block reserves in this part of an ore body. On a section the ore body No. 241 (pipe) is shown. The configuration of an ore body is changed as generally, and in details. Especially it influenced the lovation of "Uzun" flat zone. The part of an ore body (from the horizon 45-15 and below) was sharply displaced spatially. Such shift could not affect the general reserves, but spatial orientation of an ore body appeared different, than it was supposed on exploration stage.

The same refers to flat ore bodies. According to a pit data the part of a vein No. 15 was broken off and displaced, and in general coincidence satisfactory.

On an ore body No. 241 (pipe) at an operational phase considerable complications (cataclasis, distortion, etc.) are noted.

Table 1: Structural and Morphological Types of Ore Bodies of a Kochbulak Gold Ore Deposit and their Characteristic

Morpho Type	Structural Type	Shape of Ore Bodies	Average Parameters, m			Coefficient of Gold Content Variation	Distribution of Reserves, %	Group of Complexity
			Thickness	Extension				
				Strike Extension	Dip extent			
1	2	3	4	5	6	8	9	10
1st type (concertal)	Flat dipping (<45^{O}) interformational and interstratial zones of stripping branched with shear fractures	Ore chute, ore bed	1,9	113	125	150-120	22	3
	High-dipping (<45-90^{O}) radial faults, throw-overthrust branched with shear fractures	Vein	1,61	131	189	150-180	38	3
2 тип (секущие)	High-dipping (<45-90^{O}) radial explosive-brecciated transtensional faults in conjunction with branching shear fractures	Ore linear veins (pipes)	4,2	27	250	>180	40	4

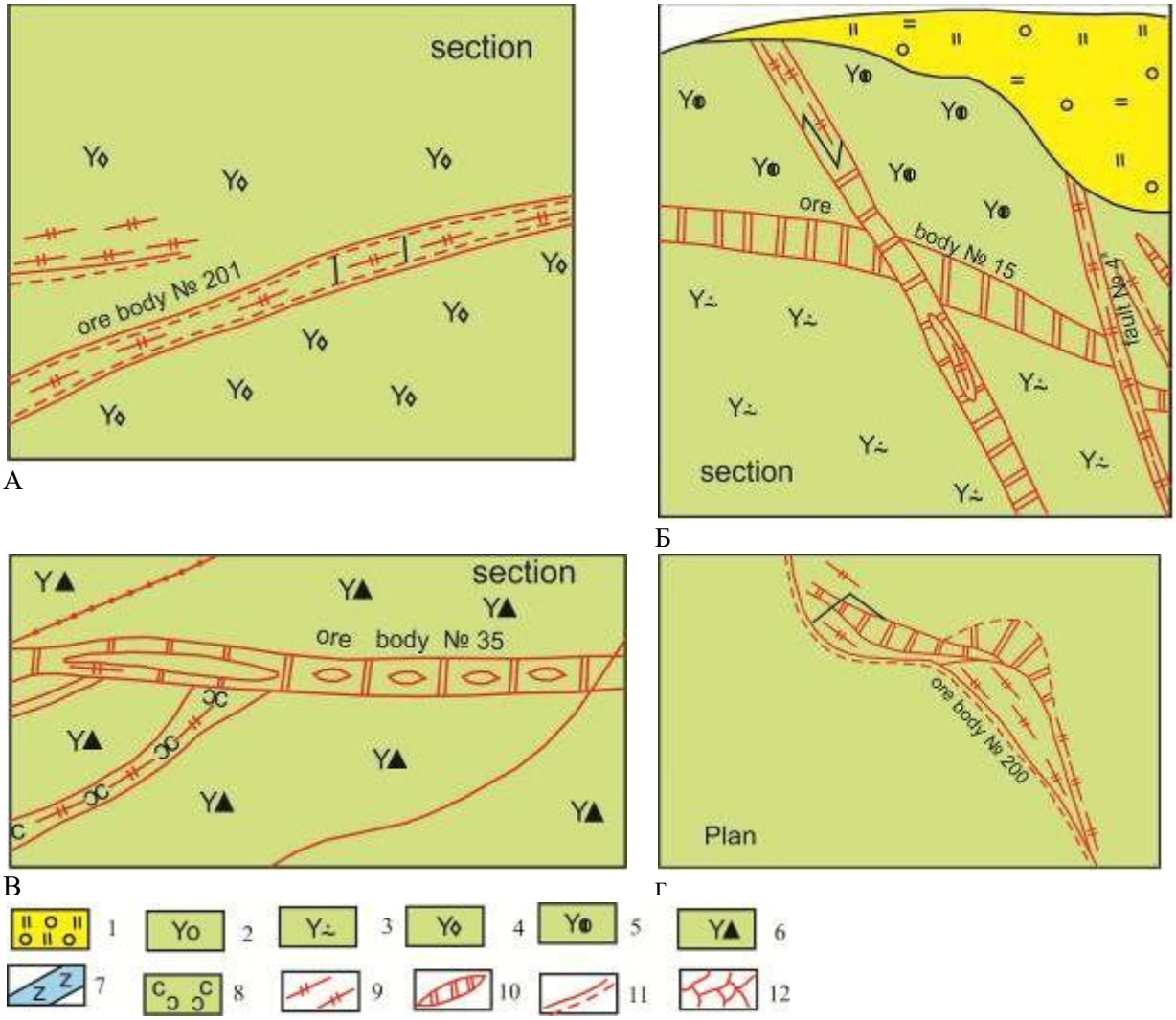


Figure 3: Geological and Structural Positions of Industrial Ores of Kochbulak Deposit (Legend: 1-Loess; 2 – Lava Breccia of Andesite Rock; 3- Lithic Tuff of Andesite Consistence; 4- Trachyandesite, Trachydacite-Andesite Porphyrites; 5- Andesite, Andesite-Dacite Porphyrites; 6- Andesite Porphyrites Corniferous and their Breccia; 7- Diabasic Breccia; 8 – Tuffite of Andesite and Andesite-Dacite Consistence; 9- Quartz Runs; 10- Quartz Veins and Lenses; 11- Fractures; Crushed Zones)

RESULTS AND DISCUSSION

Results of Application of Estimation Method

Determinated errors in gold reserve calculation depending on structural and morphological type of ore bodies of Kochbulak deposit (Table 2):

Table 2: Errors of Reserve Calculations of Kochbulak Deposit Depending on Structural and Morphological Systematization of Ore Bodies

Structural and Morphological Type	Errors of Average Contents of Gold	Errors of Reserves
Flat body	From +42% - to -36% *	From +131% - to -26%
High-dipping body	From +53,5% - to -35%	From +80% - to -29%
Chimney body	From +32% - to -28%	From +58% - to -41%

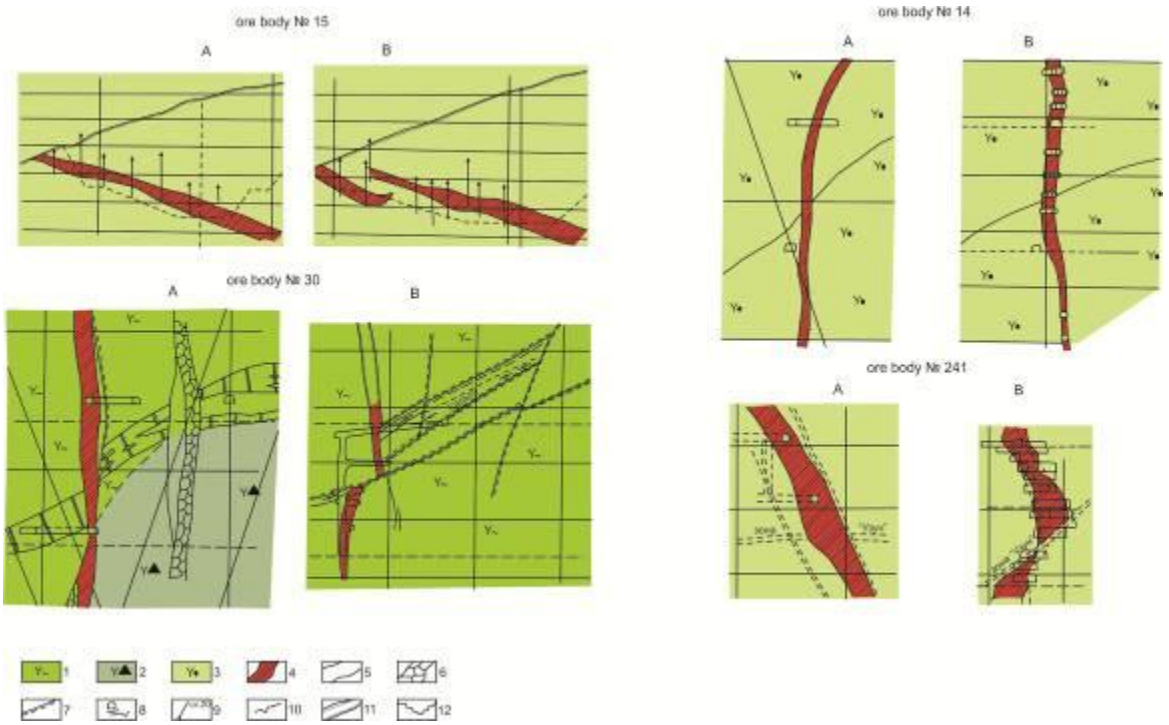


Figure 4: Change of Morphology of Ore Bodies at an Exploitation Stage
(Legend: A- According to the Exploration Data, B - According to Operation; 1- Lithic Tuff of Andesite Consistence; 2- Andesite, Andesite-Dacite Porphyrites; 3- Trachyandesite, Trachydacite-Andesite Porphyrites; 4-Ore Body; 5 Zone of an Sililicification; 6 Zone of Intensive Tectonic Crushing; 7-Faultings; 8-Underground Excavations; 9 Wells of Core Drilling; 10 Delves; 11-Old Developments; 12 Contour of a Pit)

Elicited tendency of average errors reduction with increase of exploration target (Table 3).

Table 3: Errors of Volumetric Data and Reserves Depending on Object Scale

Data	Block	Ore Body	Ore Zone
Average grade	From +28,6% - to -40,8% *	From +10,3% - to -5,6%	From +7,4% - to -28%
Gold reserves	From +57% - to -35,2%	From +18% - to -10,5%	From +10,6% - to -23,5%

*- (+) overstatement at exploration; (-) understatement at exploration

Conclusion

The structural factors played the leading role in localization of industrial ore bodies and allocation of ore-grade gold in Kochbulak deposit. These structural factors were developing against lithological factors fixed in a tendency of increase of gold content in lava breccia of andesite porphyrite and lithic tuff of andesite consistence.

In many respects influence of structural factors predetermines complications of geological borders, features of morphology, contours of ore bodies and an industrial ore-grade-gold.

Structural and morphological features of ore bodies directly influence reliability of process of delination of industrial ore-grade mineralization and estimation of average values of volumetric data.

The main reason of imbalance in estimation of blocks and ore bodies of Kochbulak deposit that makes exploration and exploitation difficult is intermitted nature of allocation of gold in ore bodies (the coefficient of a variation reaches 540%).

For Kochbulak gold deposit, it is characteristic high degree of parameter variability of ore grade mineralization, crosscutting and high-dipping nature of placement of industrial ore bodies that defines a choice of exploration system.

The following is recommended to increase degree of exploration and reserve estimation reliability on similar deposits:

1) Improvement of a technique of detailed geological and structural mapping of localization features of industrial ore-grade gold;
2) Consecutive control on identification of systematic and partial errors of various factors;
3) Accounting of an internal structure of ore bodies features at an operational phase;
4) Observance of the principle of uniform placement of prospecting and operational development in estimation blocks for the purpose of preservation of average values of reserves in space and economic profitability of their exploration;
5) Intensifications of implementation processes of the latest computer and geo information technologies, promoting high quality and on-line processing of geological information.

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